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(1)

HIGHLY ERECTABLE DOME SHELTER

Results and Recommendations of Shelter Study

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Through interviews with U.S. Air Force personnel at Tyndall Air Force Base in Florida, information has been collected and synthesized into a project program defining the Air Force's needs in fulfilling aircraft shelters at COB's. Compu-Cad, Inc. evaluated available portable shelter systems in regard to the COB needs as defined by the program. As an outcome of this evaluation, no shelter systems now available on the market meet all of the requirements. The evaluations and the program have indicated that a fabric/frame portable shelter system with modifications best meets the needs of the aircraft shelter. This report conceptualizes a brief concept of a recommended system to be developed for use as a COB shelter for A-10's, F-15's, and F-16's.

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EXECUTIVE SUMMARY

A. OBJECTIVE: The objective of this program was to identify commercially available shelters and evaluate their feasibility for housing fighter aircraft in the arctic. Those shelters would provide a protected area for aircraft maintenance and munitions loading, while also being transportable, fast erecting, and meet the necessary size and weight requirements. If such a shelter was not available, then a preliminary design would be formulated.

B. BACKGROUND: This program was initiated as a response to a logistics need submitted by Alaskan Air Command. The existing portable aircraft shelters were costly complicated to erect, and not expedient.

C. SCOPE: This program performed a market survey of available shelters to determine which ones met specific parameters for size, erectability, and mobility. The most promising candidates were thoroughly evaluated, however, each required some modification to meet project requirements. The necessary modifications were then considered in selecting a shelter to meet project needs.

D. METHODOLOGY: Within the schedule and budget of this program, two methods were available to achieve project goals. Either an original design of a shelter could be developed, or an existing commercial shelter could be adapted to shelter fighter aircraft. In this project, the identification and adaptation of commercial shelters was the chosen method. The use of existing commercial shelters was chosen because of successful, procurements costs would be greatly reduced as compared to procurement if a shelter requiring fabrication from a design.

E. TEST DESCRIPTION: No testing was performed on this project

F. RESULTS: Based on the market survey, no shelter meeting all Air Force requirements is available. Generally, the available shelters were either too large or too small. Door openings, unobstructed working space, and ease of erection were formidable obstacles. Three viable candidates were identified, and with design modifications could meet Air Force requirements. All three vendors indicated a willingness and ability to provide the shelter we desired.

G. CONCLUSIONS: A rapidly erectable fighter Aircraft shelter for use in the arctic can be developed. This shelter would be of great benefit to units deploying to Collocated Operating Bases, where aircraft hangars may not be in place. In severe cold, hot, or wet environments, the lack of hangar space is very critical.

H. RECOMMENDATIONS: Although a need for this shelter has been expressed by Alaskian Air Command, no formal endorsement of the program has been received by the MAJCOM. Some shelters exist that could house some of the Alaskan Fighter aircraft exist, but none that would meet the size requirements of all fighter aircraft currently used in Alaska. This program has left us at a good starting point to do development on such a shelter if the priority of the effort was increased. Further research would be developing the shelter modifications necessary to meet the shelter needs.

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PREFACE

This report was prepared by COMPU-CAD, INC., 20 Constitution Drive, Taunton, MA 02780, under contract number F08635-88-C-0296. This work was sponsored by the Air Force Engineering and Services Center, Directorate of Engineering and Services Laboratory (HQ AFESC/RD), Tyndall Air Force Base, Florida 32403-6001.

Captain Richard Reid (AFESC/RD) served as project officer. This report summarizes the work accomplished between 29 August 1988 and 28 March 1989.

This report has been reviewed by the Pubic Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

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SECTION I

INTRODUCTION

A. OBJECTIVE

The requirement to perform engine maintenance and rapid loading of munitions on various aircraft (F-15, F-16, A-10) in regions of extreme cold weather has prompted a market survey and investigation to explore the existence of a highly erectable dome type shelter which is commercially available and meets Air Force requirements. This report summarizes the findings of the market survey and subsequent investigation.

There were two main objectives to this endeavor. The first objective was to find a shelter encompassing all of the design and performance characteristics required by the Air Force. This included consideration of size and weight, ease of erection, air transportability, ability to withstand extreme environmental conditions in various climate zones, ability to keep personnel comfortable, and allowance of 24-hour maintenance and munitions loading.

The second objective was to provide a preliminary design for such a shelter should none be presently available. The goal in either case was the same– to provide the Air Force with a shelter to meet its needs.

B. BACKGROUND

In reviewing the requirements for the shelter, various conditions, including climate and different aircraft configurations posed interesting challenges. This investigation addressed each of the challenges discussed below.

One of the main challenges this project presented was the conflict between the desire for a durable, habitable shelter and the requirement for it to be lightweight and mobile. Many design elements which improve durability of components (i.e., fabric and frame) and control climate, add weight and volume, thus affecting mobility.

Also of concern was how the required opening width and unobstructed floor space reflected on truss or beam size. It had to be determined whether air-supported or metal beams could provide the widest span.

With the proposed shelter, Air Force personnel must be able to perform 24-hour maintenance on aircraft regardless of environmental conditions, including tropical zones ranging from humid jungle to arid desert and the arctic.

An example of the importance of this endeavor is the problem experienced in Vietnam when extreme heat from the sun elevated skin temperatures of helicopters to approximately 110°F. Personnel were restricted to performing maintenance after sundown or in the early morning. The tropical conditions also affected the men physically, decreasing their work performances.

Effects of snow loads, winds loads, and temperature on structure and textiles were considered. In the late 1960s, Mr. Ernest Saab, one of our principal investigators, was involved in a study at the U.S. Army Natick Research, Development, and Engineering Center (NRDEC) which examined coated fabric behavior in extreme cold temperatures. The study compared plasticized material (i.e., vinyl) and synthetic rubber-coated material (i.e., neoprene) on air-supported shelters such as the Pershing Missile tent (Reference 1). The results of the study indicated that neoprene-coated fabrics are far superior to vinyl-coated fabrics. The major drawback to neoprene coating was that during fabrication of the seams, seam joint areas had to be abraded, washed, dried, and several coats of adhesive applied with drytime in between coats. This process was slow and expensive.

Since that study, new fabric coatings have been developed using urethane which have proved superior to neoprene. These fabrics also lend themselves to heat sealing or electronic welding rather than sewing or cementing during fabrication. Our team of investigators used this knowledge during examination of shelters to assure that the latest technology was used.

Utilization of liners improves the efficiency of both heating and cooling systems, reducing size and power requirements of equipment and operating costs. A study conducted at NRDEC analyzed the effect of various design alternatives on the thermal microclimate of a frame-supported tent (Reference 2). The prime objective of this study was to improve the thermal comfort of occupants in both hot and cold weather. Tents were modified to include various vent, fly, and liner (plain and insulated) configurations.

Mr. Saab, then chief of the prototype branch at NRDEC, participated in the study by suggesting materials, making modifications to the tents, and fabricating the liners used. CCI made use of this study which proved that power consumption of electric heating equipment was remarkably improved through the use of liners ranging from plain sheet to insulated blankets. (Electric heating units were used to perform the tests because the amount of power consumed could be accurately measured).

C. SCOPE

COMPU-CAD, INCORPORATED (CCI) conducted a comprehensive survey, and an in-depth analysis on the above. The results, as portrayed in this report, will serve to accomplish the intent of the contract.

SECTION II

MARKETING SURVEY

A. APPROACH

The approach taken by CCI in addressing the problems posed by the contract requirements was to identify all types of shelters available within certain specific parameters and to compile a list of state-of-the-art shelters. CCI conducted a market survey to find a vendor(s) who could supply an "off-the-shelf" shelter that meets the Air Force's requirements.

1. Initial Questionnaire

The first step of the market survey was to prepare a questionnaire describing the performance objectives required of a shelter to qualify as a viable candidate. The list was compiled by Mr. Saab who is experienced in procuring shelter items for the U.S. Army, and has used his past experience to cover all aspects of the shelter requirements.

The questionnaire stated that in order to house an A-10, F-15, or F-16 aircraft, the shelter system must have the following dimensions as a minimum (obtained from Jane's Aircraft Book):

- 100 feet long (enough to house two aircraft)
- 65 feet wide (A-10 wingspan is 54 feet, 8 inches)
- 25 feet high (five feet each side of center; F-15 has twin fins)

The questionnaire also stated that the shelter had to:

- Be erectable in a 12-hour time period with a minimum of unskilled personnel (6 to 10, depending on size of shelter and weather conditions) without requiring special tools or equipment (i.e., forklifts or cranes) at unprepared sites
- Protect personnel from the climate and provide for a comfortable working environment using liners, air-conditioning, and heating units (humidifying or dehumidifying units can be added if required)
- Have wide, unobstructed interior floor space (approximately 6500 square feet) free of structural members

- Be lightweight - 100 pounds per component of the tent (max). The maximum length of each component should be approximately 12 feet
- Withstand snow loads of 10 lbs/sq ft
- Withstand wind loads of 50 mph with gusts to 65 mph
- Have . fabric that will withstand abuse in handling during erection, dismantling, and packing for transportation
- Have a life cycle of 3 to 5 years with 4 to 6 erections per year and a storage life of 10 to 15 years
- Be available in multiple heights and widths to allow other Government agencies and the private sector to use it

CCI prepared and sent a questionnaire to 182 prospects (Appendix A). The manufacturers were obtained from several reference books (References 3 and 4) and our project manager's knowledge of tentage manufacturers. To assist COMPU-CAD, INC. in the selection of the most viable candidate(s), a baseline requirements chart was created with 16 pieces of information to be filled in for each candidate. That information is as follows:

1. Type of shelter
2. Site preparation requirements
3. Number of personnel required to erect/dismantel shelter
4. Time required to erect/strike shelter
5. Special equipment required to erect shelter
6. Does shelter meet 10 lbs/sq ft. snow load requirements
7. Does shelter meet 50 mph steady, 65 mph gusts wind load requirements
8. Does the shelter have aircraft type doorway
9. Does vendor have a shelter on hand to meet the requirements
10. Extent of modification needed to meet requirements
11. Can shelter be shipped on a 463L pallet
12. Can shelter be shipped in a standard 8 x 8 x 20 container
13. Are loose parts captivated
14. Approximate weight of heaviest component
15. Approximate shipping weight
16. Approximate shipping cube

The responses from the first questionnaire seemed at first to indicate that a commercially available shelter did exist. However, after closer scrutiny and contact with the manufacturer(s), the potential for an off-the-shelf shelter system seemed remote.

Of the 182 companies surveyed, approximately 38 companies had a shelter that, with some modification, could possibly meet the requirements set forth in the contract. The investigation produced a basic concept which would meet Air Force requirements (Figure 1).

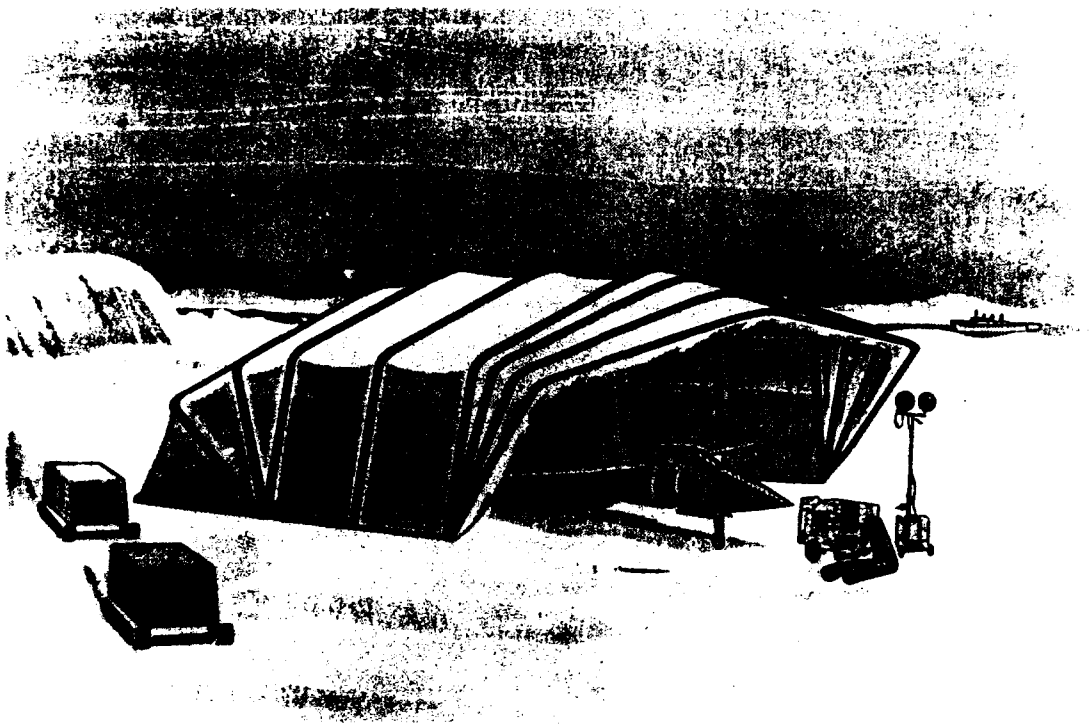

Figure 1. CCI's Concept for a Shelter with a Wide Opening, Folding Door, Possible Lighting, and Heating/Cooling Systems

2. Second Questionnaire

CCI carefully investigated the 38 potential shelters and determined that 15 vendors had good, usable shelters that could be considered. A follow-up questionnaire and cover letter were prepared and sent to the 15 companies deemed potential candidates. This letter requested more specific details from vendors on their shelters (Appendix B).

B. DATA BASE OF VENDORS

The information received from the 15 vendors was reviewed to ascertain the most viable shelter candidate(s) that could meet all or most of the requirements. COMPU-CAD, INC. was looking for a vendor stocking a shelter that required the least amount of man hours to erect/strike and that did not require special equipment (i.e., cranes) to erect it. For mobility purposes, it should be able to be transported on a 463L pallet. Not of least importance was the number of loose parts, and their ability to be captured.

The results of investigation of the 15 potential companies are listed on the following pages. A data base and a figure depicting the shelter is provided for each manufacturer. The data were obtained from brochures, telephone conversations, written communication, and personal visits.

1. CHEMFAB, Buffalo, New York

Mr. Ernest Saab and Mr. Richard Brilhante visited CHEMFAB in February 1989 and found that the Mark 66 shelter provides unique features such as a pivot point for arches, few assembly parts, and a clamshell type door (Figure 2). However, the company is reluctant to revive this structure which was originally a product of Bird-Air Corporation. CHEMFAB is mainly a producer of Teflon®-coated fiberglass materials and would require the use of their fabric in a larger structure. This material could not withstand the abuse it would receive during the required four erection cycles per year.

Type of Shelter	Frame and fabric-tensioned structure.
Site Preparation	Same as an airfield.
Number of People to Erect Shelter	8 to 10
Number of Hours to Erect Shelter	20 to 24
Number of Hours to Dismantle Shelter	10
Special Equipment Required	Depending on the zone and/or soil conditions, different anchor-driving equipment will be required other than a sledge hammer (i.e., electric or gasoline hammer or auger-type drill).
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	Yes
An "Off-the Shelf" Item	Yes. (The last shelter of this type was built in 1966 for the Army helicopter school in Fort Rucke, AL.)
Type of Modification Required	Must be made larger to meet requirements.
Can be Shipped on a 463L Pallet	No. Can be redesigned to fit on a pallet.
Shipped in an 8 by 8 by 20 ISO Container	Yes
Approx. Weight of Heaviest Item	200 pounds
Approx. Shipping Weight	9500 pounds
Approx. Cubic Feet	450
Captive Fastening Devices	Yes

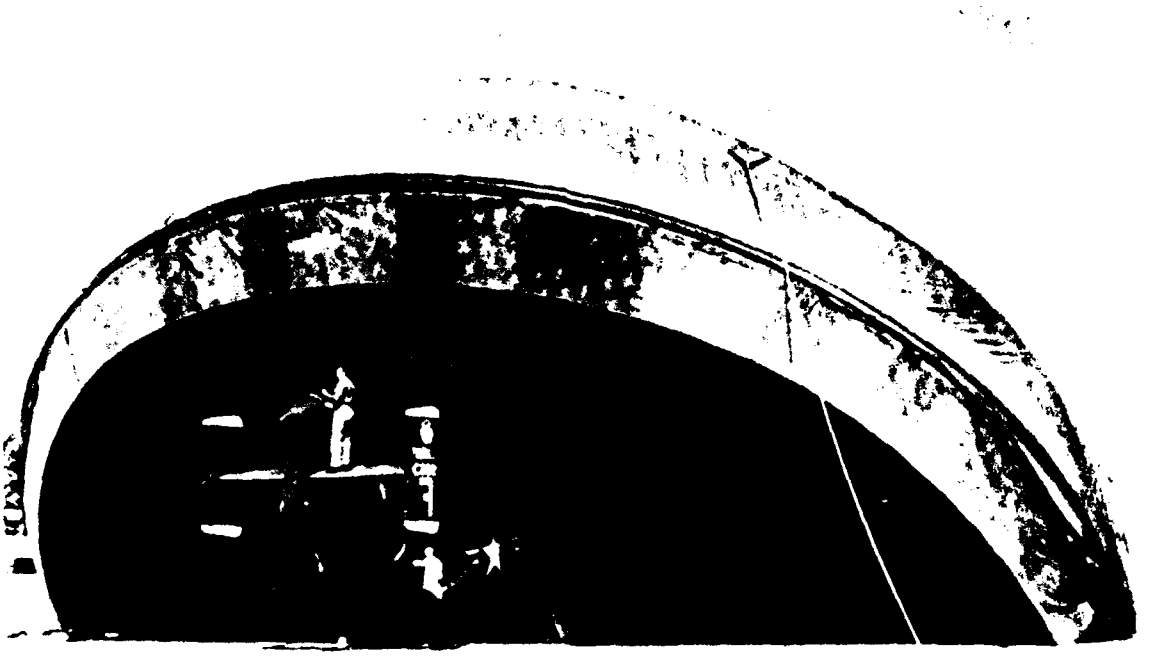

Figure 2. Rendering of CHEMFAB's Shelter

2. ARCH TECHNOLOGY, Plato Center, Illinois

This company's shelter is made of corrugated steel and requires numerous nuts and bolts to assemble the shelter, making it difficult to capture the hardware (Figure 3). Large mittens would make it very difficult to use small hand tools if the Air Force erected this shelter in the arctic area. It also requires ladders and scaffolds to erect and dismantle. The configuration of this shelter does not lend itself easily to a designed door that would accept the designated aircraft. This shelter is more suited to special adaptations such as hardened, underground or a more permanent installation.

Type of Shelter	Corrugated galvanized steel structure
Site Preparation	Same as an airfield
Number of People to Erect Shelter	8 to 10
Number of Hours to Erect Shelter	40 to 48
Number of Hours to Dismantle Shelter	20
Special Equipment Required	Scaffolding. Depending on the zone and/or soil conditions, different types of anchor-driving equipment will be required other than a sledge hammer (i.e., electric or gasoline hammer or auger-type drill).
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	No
An "Off-the Shelf" Item	Yes
Type of Modification Required	Design door to accept aircraft.
Can be Shipped on a 463L Pallet	Yes
Shipped in an 8 by 8 by 20 ISO Container	Yes
Approx. Weight of Heaviest Item	100 pounds
Approx. Shipping Weight	28,000 pounds
Approx. Cubic Feet	1,200
Captive Fastening Devices	No, captive fasteners would have to be designed.

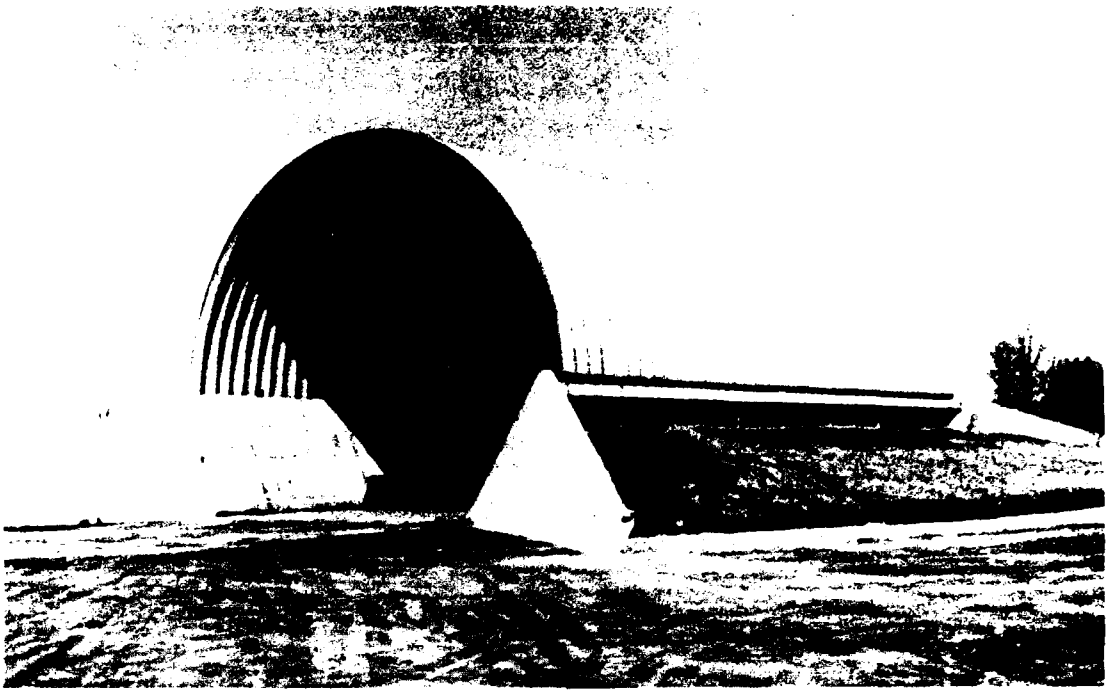

Figure 3. Rendering of ARCH TECHNOLOGY's Shelter

3. LITTLE RIVER INDUSTRIES INC., Quincy, Florida

This company's shelter consists of spring steel tubing covered with a light weight vinyl fabric (Figure 4). The shelter is primarily used for storage and/or sunshield and only has door openings for equipment and personnel. To meet Air Force requirements, the frame and fabric would have to be reengineered, and a door designed to accept the designated aircraft.

Type of Shelter	Spring steel tubing and fabric tensioned structure.
Site Preparation	Same as an airfield
Number of People to Erect Shelter	6 to 8
Number of Hours to Erect Shelter	12 to 16
Number of Hours to Dismantle Shelter	8 to 10
Special Equipment Required	Scaffolding and ladders. Depending on the zone and/or soil conditions, different types of anchor-driving equipment will be required other than a sledge hammer (i.e., electric or gasoline hammer or auger-type drill).
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	No
An "Off-the Shelf" Item	Yes
Type of Modification Required	Design of aircraft door and arches.
Can be Shipped on a 463L Pallet	No, the arches would have to be redesigned to fit on the pallet.
Shipped in an 8 by 8 by 20 ISO Container	Yes
Approx. Weight of Heaviest Item	150 pounds
Approx. Shipping Weight	10,000 pounds
Approx. Cubic Feet	450
Captive Fastening Devices	No, Captive fasteners would have to be designed.

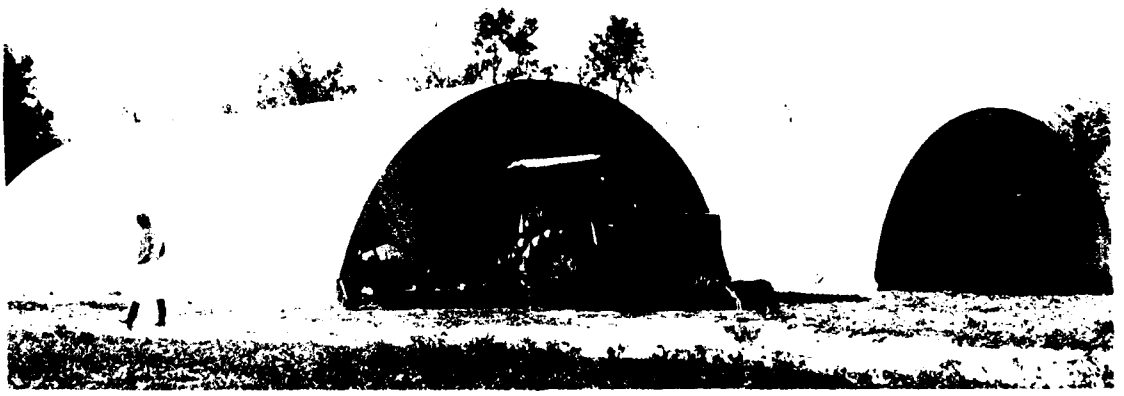

Figure 4. Rendering of LITTLE RIVER's Shelter

4. HOECKER, INC., Union, Kentucky

This company's shelter has a steel rectangular frame with tensioned fabric (Figure 5). The roof beams, because of their length, would have to be redesigned to be shipped in an International Standardization Organization (ISO) shelter or a 463L pallet. This shelter design has support cables at the eaves which would prevent the entrance of the aircraft. Their present door would have to be redesigned to accept the aircraft.

Type of Shelter	Steel frame and tensioned fabric structure
Site Preparation	Same as an [illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible] or gas-driven hammer or auger-type drill).
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	No
An "Off-the Shelf" Item	Yes
Type of Modification Required	Design door to accept aircraft and relocate eave cables.
Can be Shipped on a 463L Pallet	No, components would have to be redesigned to fit shipping mode.
Shipped in an 8 by 8 by 20 ISO Container	No, components would have to be redesigned to fit shipping mode.
Approx. Weight of Heaviest Item	200 pounds
Approx. Shipping Weight	32,000 pounds
Approx. Cubic Feet	1800
Captive Fastening Devices	No, Captive fasteners would have to be designed.

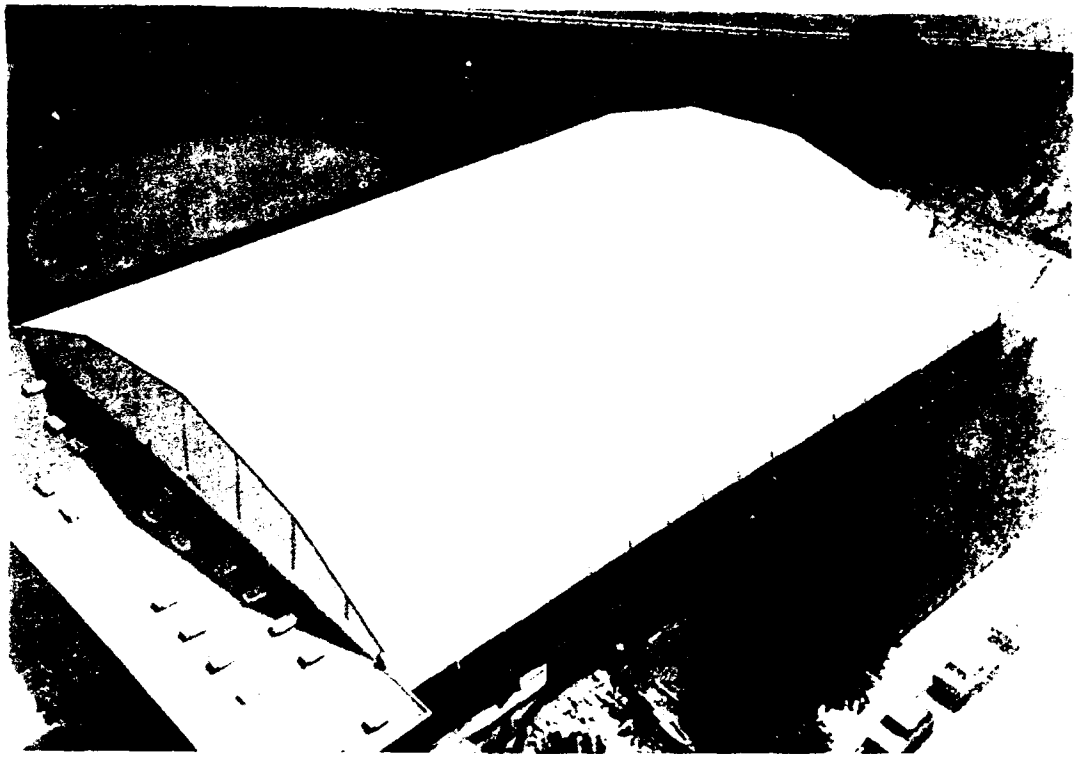

Figure 5. Rendering of HOECKER's Shelter

5. RODER, USA, Laguna Beach, California

This company has two concepts for a shelter: 1) a shelter similar to Hoecker's, and 2) a polygon type structure with a clamshell door (Figure 6). Both have a rectangular frame with tensioned fabric. In either case, the size of the shelter would have to be made to order. The polygon type shelter, per the company's statement, does not specify snow load and is in the conceptual stages of manufacture. A door to accept the designated aircraft would have to be designed.

Type of Shelter	Polygram type frame with tensioned fabric structure.
Site Preparation	Same as an airfield.
Number of People to Erect Shelter	6 to 8
Number of Hours to Erect Shelter	12 to 16
Number of Hours to Dismantle Shelter	8 to 10
Special Equipment Required	Depending on the zone and/or soil conditions, different types of anchor-driving equipment will be required other than a sledge hammer (i.e., electric or gasoline hammer or auger-type drill).
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	No
An "Off-the Shelf" Item	Yes
Type of Modification Required	Design aircraft door.
Can be Shipped on a 463L Pallet	No, redesign of arch members required.
Shipped in an 8 by 8 by 20 ISO Container	Yes
Approx. Weight of Heaviest Item	175 pounds
Approx. Shipping Weight	22,000 pounds
Approx. Cubic Feet	1,500
Captive Fastening Devices	No, captive fasteners would have to be designed.

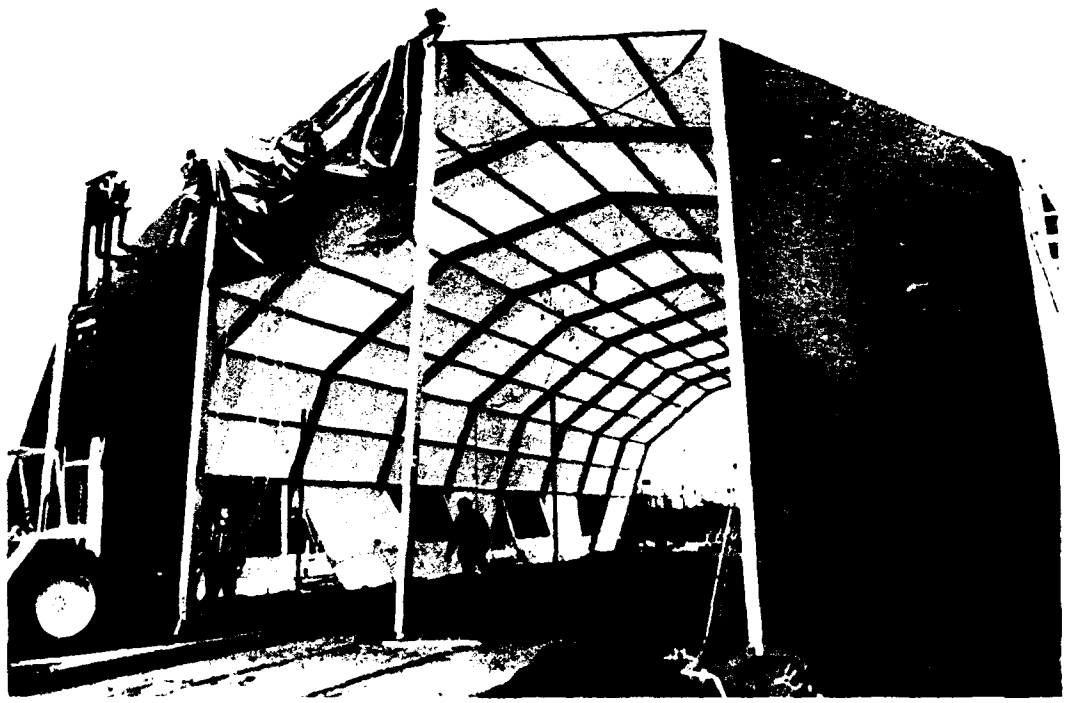

Figure 6. Rendering of RODER's Shelter

6. LOSBERGER, INC., West Germany

LOSBERGER's shelter is similar to those of Hoecker and Roder (Figure 7). It has a rectangular aluminum frame with tensioned fabric and cables across the eaves which would restrict the entrance of aircraft. Mr. Inge Schmidts, a company representative, stated that LOSBERGER would build the shelter, but would not design a door to accept the designated aircraft. The Air Force would have to purchase the aircraft door from another vendor.

Type of Shelter	Frame and tensioned fabric structure.
Site Preparation	Same as an airfield.
Number of People to Erect Shelter	6 to 8
Number of Hours to Erect Shelter	12 to 16
Number of Hours to Dismantle Shelter	8 to 10
Special Equipment Required	Crane or forklift. Depending on the zone and/or soil conditions, different types of anchor-driving equipment will be required other than a sledge hammer (i.e., electric or gasoline hammer or auger-type drill).
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	No
An "Off-the Shelf" Item	Yes
Type of Modification Required	Design aircraft door and relocate eave cables.
Can be Shipped on a 463L Pallet	No, redesign of arch members required.
Shipped in an 8 by 8 by 20 ISO Container	No, redesign of arch members required.
Approx. Weight of Heaviest Item	200 pounds
Approx. Shipping Weight	18,000 pounds
Approx. Cubic Feet	1,200
Captive Fastening Devices	No, captive fasteners would have to be designed.

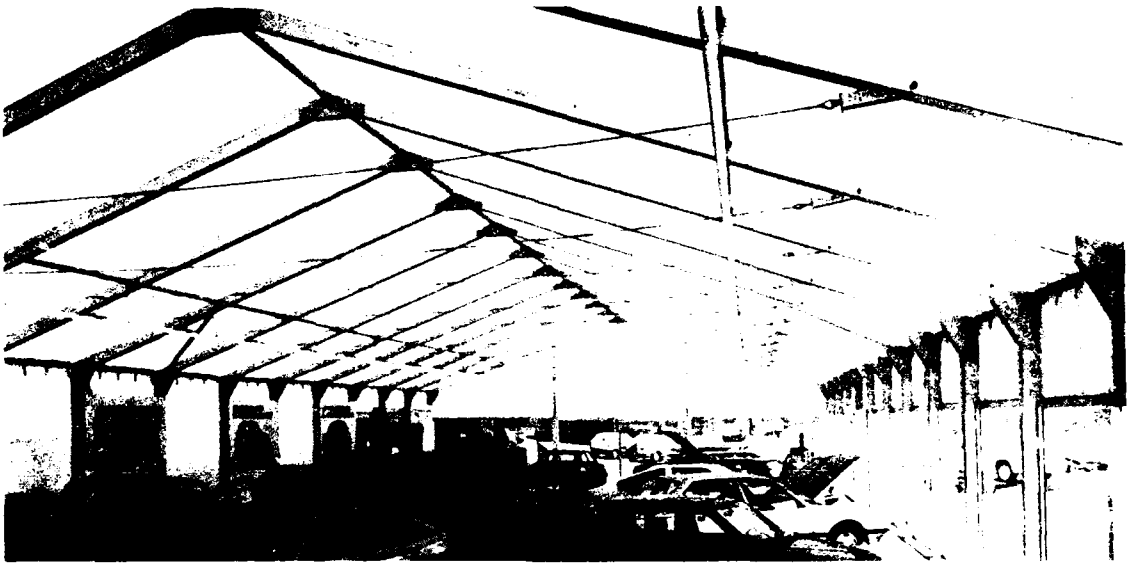

Figure 7. Rendering of LOSBERGER's Shelter

7. ATCO STRUCTURES, Aurora, Colorado

This company's shelter concept is a fold a way galvanized panel building (Figure 8). The roof and side panels are hinged together which requires a prepared site and a heavy duty crane (20,000 pounds with a 50-foot boom, heavy sling, and a spreader bar) to lift it into place. These components cannot be shipped on a 463L pallet or an ISO shelter. They require a 40-foot flatbed truck, or for air delivery, a C-141 aircraft. A door would also have to be designed to accept the designated aircraft.

Type of Shelter	Galvanized steel hinged panels type structure.
Site Preparation	Concrete footing is required.
Number of People to Erect Shelter	6 to 8
Number of Hours to Erect Shelter	28 to 32
Number of Hours to Dismantle Shelter	16 to 20
Special Equipment Required	20,000 lb crane
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	No
An "Off-the Shelf" Item	Yes
Type of Modification Required	Design aircraft door.
Can be Shipped on a 463L Pallet	No
Shipped in an 8 by 8 by 20 ISO Container	No, but can be shipped in a 40 foot ISO container.
Approx. Weight of Heaviest Item	6,000 pounds
Approx. Shipping Weight	65,000 pounds
Approx. Cubic Feet	9,600
Captive Fastening Devices	No, captive fasteners would have to be designed.

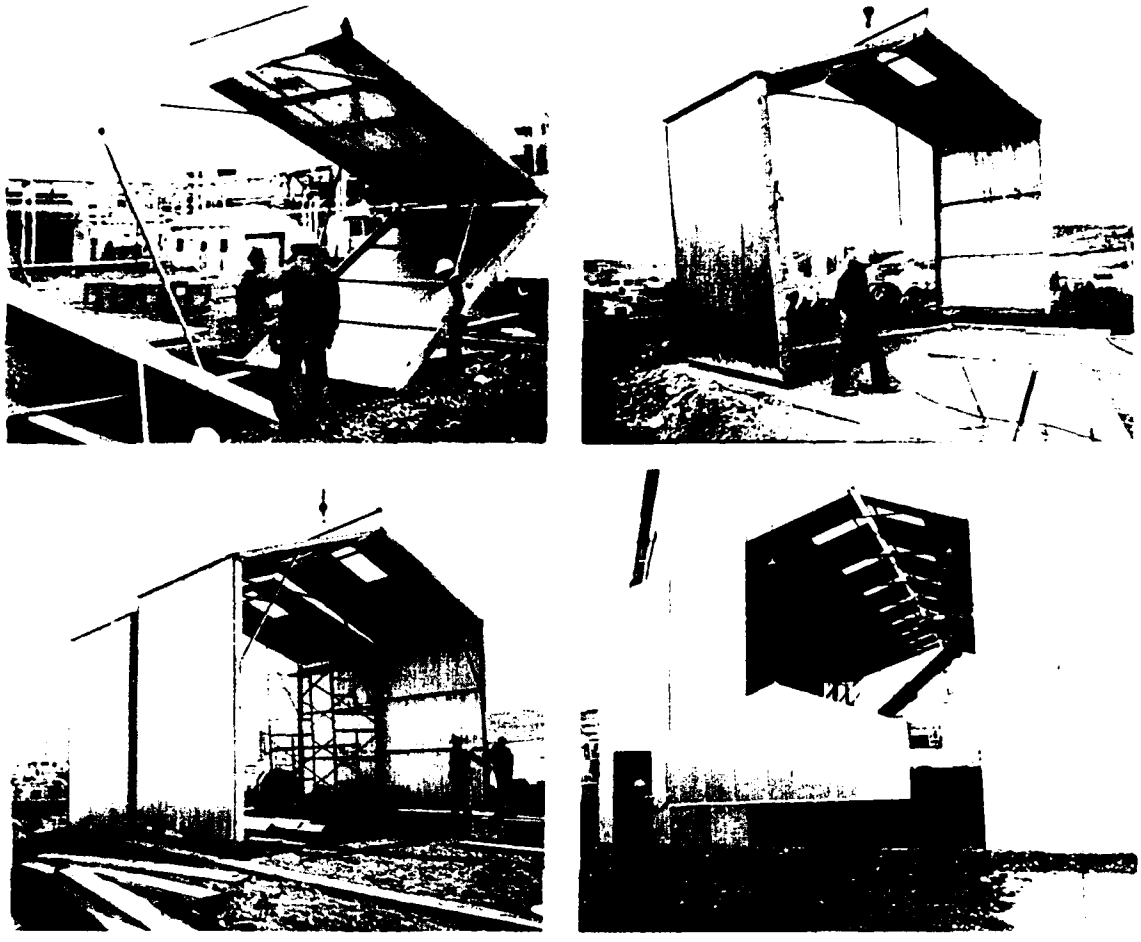

Figure 8. Rendering of ATCO Structures' Shelter

8. WARNER FABRIC STRUCTURES, Vancouver, B.C.

This company's shelter consists of a pipe truss frame and tensioned fabric (Figure 9). The height of the shelter, 23 feet, is 2 feet lower than the required height. This shelter would have to be redesigned in three areas: the side wall would have to be raised, a door designed to accept the designated aircraft, and loose parts would have to be captured. The shelter requires a fork lift or crane to raise the arches.

Type of Shelter	Truss frame and tensioned fabric structure.
Site Preparation	Same as an airfield.
Number of People to Erect Shelter	6 to 8
Number of Hours to Erect Shelter	20 to 24
Number of Hours to Dismantle Shelter	12 to 16
Special Equipment Required	Forklift or crane. Depending on the zone and/or soil conditions, different types of anchor-driving equipment will be required other than a sledge hammer (i.e., electric or gasoline hammer or auger-type drill).
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	No
An "Off-the Shelf" Item	Yes
Type of Modification Required	Design aircraft door.
Can be Shipped on a 463L Pallet	No, must be redesigned.
Shipped in an 8 by 8 by 20 ISO Container	Yes
Approx. Weight of Heaviest Item	200 pounds
Approx. Shipping Weight	21,000 pounds
Approx. Cubic Feet	1,000
Captive Fastening Devices	No, captive fasteners would have to be designed.

Figure 9. Rendering of WARNER FABRIC STRUCTURES' Shelter

9. ERECT-A-TUBE, Harvard, Illinois

This company's shelter is a prefabricated, aluminum alloy, panelized building (Figure 10). Extensive ground preparation (i.e., concrete footing) is required. The components of the shelter are heavy and require a 10,000-pound crane to lift them into place. The shelter comes with an electric bifold or a roll-type hanger door. In either case, the present doors would have to be redesigned to accept the designated aircraft. In addition, loose components would have to be secured. This shelter does not lend itself to be shipped on a 463L pallet, however, it could be redesigned to fit into a standard ISO container.

Type of Shelter	Aluminum alloy panel-type structure.
Site Preparation	Footing preparation.
Number of People to Erect Shelter	6 to 8
Number of Hours to Erect Shelter	24 to 30
Number of Hours to Dismantle Shelter	16 to 20
Special Equipment Required	10,000 lb crane.
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	Yes
An "Off-the Shelf" Item	Yes
Type of Modification Required	Redesign door to accept aircraft.
Can be Shipped on a 463L Pallet	No
Shipped in an 8 by 8 by 20 ISO Container	No
Approx. Weight of Heaviest Item	5,000 pounds
Approx. Shipping Weight	40,000 pounds
Approx. Cubic Feet	2,550
Captive Fastening Devices	No, captive fasteners would have to be designed.

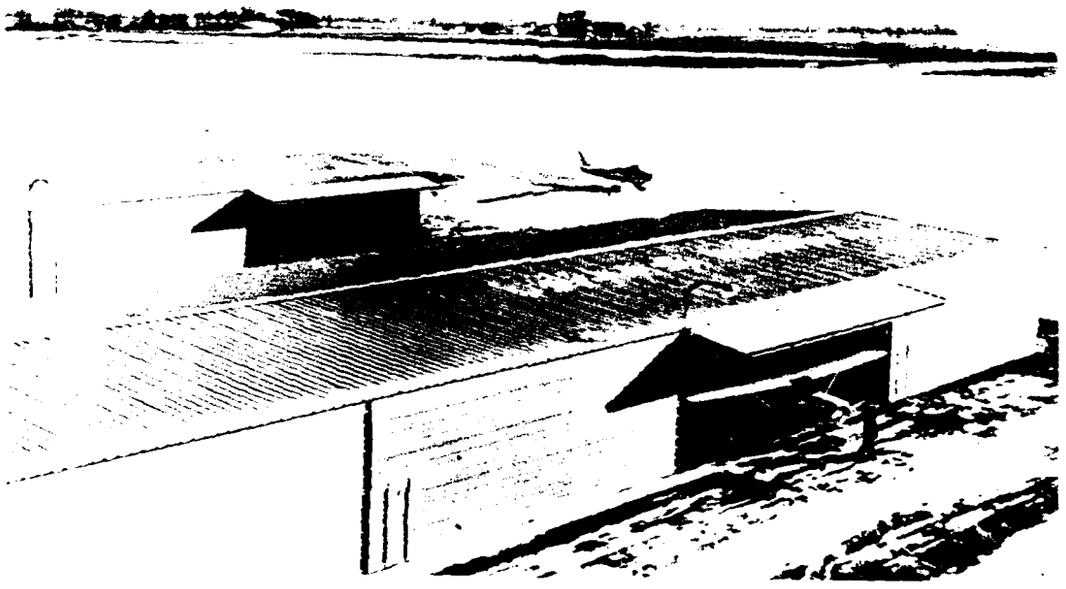

Figure 10. Rendering of ERECT-A-TUBE's Shelter

10. SPRUNG INSTANT STRUCTURES, Calgary, Alberta, Canada

This company's shelter utilizes an aluminum alloy I-Beam frame covered with tensioned fabric (Figure 11). Due to the problems of snow loading, the company has switched from a Herculite fabric to Tedlar® fabric because tests proved that the Tedlar® fabric had the lowest friction coefficient and allowed snow to start sliding at an angle as low as 4 degrees. It requires a small crane or fork lift to pick up the assembled arches, and a scaffold to join components. A door would have to be designed to accept the designated aircraft.

Type of Shelter	Frame and tensioned fabric structure.
Site Preparation	Same as an airfield.
Number of People to Erect Shelter	6 to 8
Number of Hours to Erect Shelter	24 to 36
Number of Hours to Dismantle Shelter	16 to 20
Special Equipment Required	Crane or forklift and scaffolding. Depending on the zone and/or soil conditions, different types of anchor-driving equipment will be required other than a sledge hammer (i.e., electric or gasoline hammer or auger-type drill).
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	No
An "Off-the Shelf" Item	Yes
Type of Modification Required	Design aircraft door.
Can be Shipped on a 463L Pallet	No
Shipped in an 8 by 8 by 20 ISO Container	Yes
Approx. Weight of Heaviest Item	200 pounds
Approx. Shipping Weight	3,600 pounds
Approx. Cubic Feet	2,100
Captive Fastening Devices	No, captive fasteners would have to be designed.

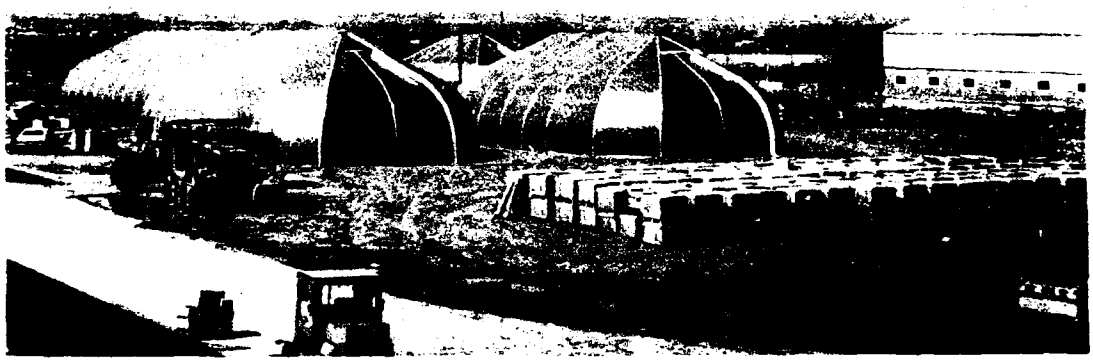

Figure 11. Rendering of SPRUNG INSTANT STRUCTURES' Shelter

11. NORDAM, Tulsa, Oklahoma

This company's shelter utilizes aluminum alloy, paper honeycomb 4 by 8 panels for the body of the shelter (Figure 12). These panel arches are joined together by a coated fabric band which serves as a weather barrier and a trough to channel the rain. The clamshell door is assembled by joining contoured beams that are connected with tapered panels. A series of these panels are joined at a pivot point at each side of the opening. This shelter requires a crane to assemble.

Type of Shelter	Aluminum alloy Honeycomb panel structures with a clamshell type door.
Site Preparation	Same as an airfield.
Number of People to Erect Shelter	8 to 10
Number of Hours to Erect Shelter	24 to 36
Number of Hours to Dismantle Shelter	16 to 20
Special Equipment Required	Crane or forklift. Depending on the zone and/or soil conditions, different types of anchor-driving equipment will be required other than a sledge hammer (i.e., electric or gasoline hammer or auger-type drill).
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	Yes
An "Off-the Shelf" Item	Yes
Type of Modification Required	Capturing of loose component parts.
Can be Shipped on a 463L Pallet	Yes
Shipped in an 8 by 8 by 20 ISO Container	Yes
Approx. Weight of Heaviest Item	300 pounds
Approx. Shipping Weight	25,000 pounds
Approx. Cubic Feet	1,500
Captive Fastening Devices	No, captive fasteners would have to be designed.

Figure 12. Rendering of NORDAM's Shelter

12. AERODOME, Wichita, Kansas

This company's shelter is circular and has an electrically-operated rotating floor and a bifold door (Figure 13). It can be fabricated from fiberglass or steel panels. The disadvantage of this shelter is that it requires extensive site preparation, including a raised foundation, to provide the required door height. This shelter is a prime candidate for a fixed installation, however, this study requires the shelter to be relocatable and not require heavy equipment.

Type of Shelter	Fiberglass or steel panels structure.
Site Preparation	Concrete foundation.
Number of People to Erect Shelter	6 to 8
Number of Hours to Erect Shelter	24 to 30
Number of Hours to Dismantle Shelter	16 to 20
Special Equipment Required	Crane. Depending on the zone and/or soil conditions, different types of anchor-driving equipment will be required other than a sledge hammer (i.e., electric or gasoline hammer or auger-type drill).
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	Yes
An "Off-the Shelf" Item	Yes
Type of Modification Required	Redesign door to accept aircraft.
Can be Shipped on a 463L Pallet	No
Shipped in an 8 by 8 by 20 ISO Container	No
Approx. Weight of Heaviest Item	750 pounds
Approx. Shipping Weight	30,000 pounds
Approx. Cubic Feet	1,750
Captive Fastening Devices	No, captive fasteners would have to be designed.

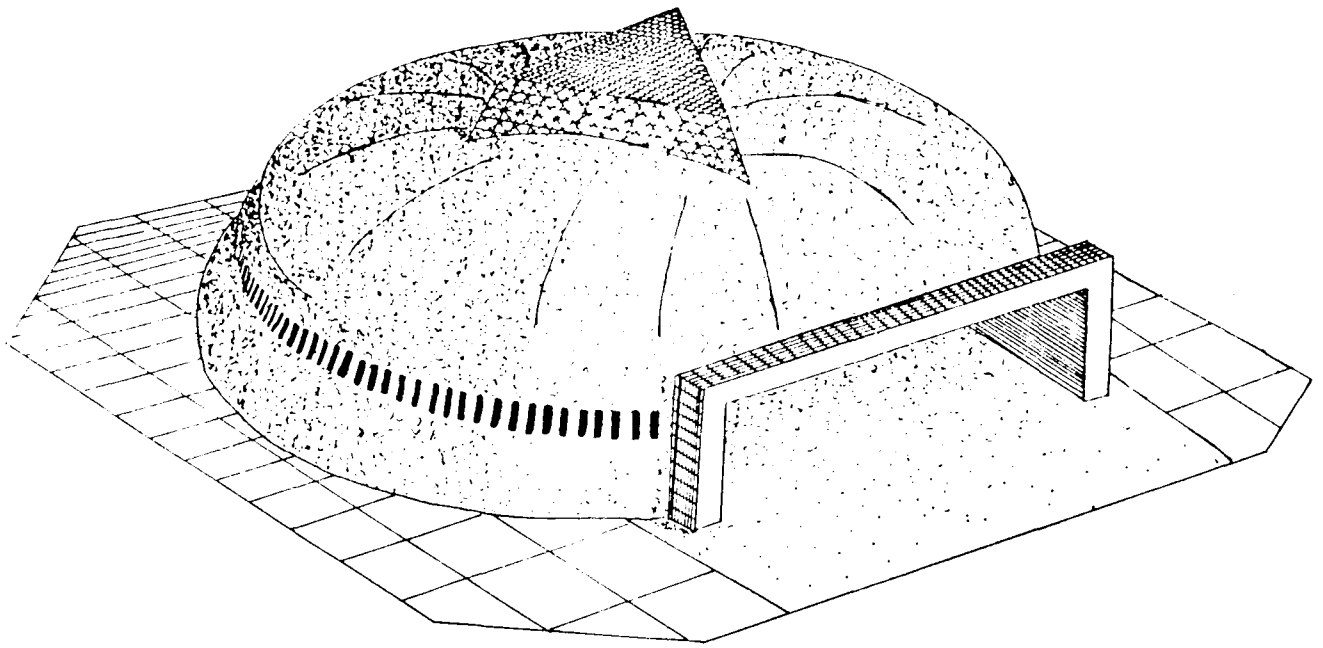

Figure 13. Rendering of AERODOME's Shelter

13. TENSAR STRUCTURES, INC., Akron, New York

This company is presently building a prototype shelter 73 feet wide by 103 feet long by 37 feet high with a clamshell-type door opening of 70 feet for use by the Navy (Figure 14). The frame is an aluminum alloy I-Beam construction (with a 12-inch web) which is overly designed for our loading requirements. This shelter frame can be erected from the ground without the need of a crane. By modifying the I-Beams to meet our loading requirements, the shelter would meet the Air Force's requirements.

Type of Shelter	Frame and tensioned fabric structure.
Site Preparation	Same as an airfield.
Number of People to Erect Shelter	6 to 8
Number of Hours to Erect Shelter	10 to 12
Number of Hours to Dismantle Shelter	8 to 10
Special Equipment Required	Depending on the zone and/or soil conditions, different types of anchor-driving equipment will be required other than a sledge hammer (i.e., electric or gasoline hammer or auger-type drill).
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	Yes
An "Off-the Shelf" Item	Yes
Type of Modification Required	Reduce the size of I-Beam web.
Can be Shipped on a 463L Pallet	Yes
Shipped in an 8 by 8 by 20 ISO Container	Yes
Approx. Weight of Heaviest Item	200 pounds
Approx. Shipping Weight	23,250 pounds
Approx. Cubic Feet	1,125
Captive Fastening Devices	Yes

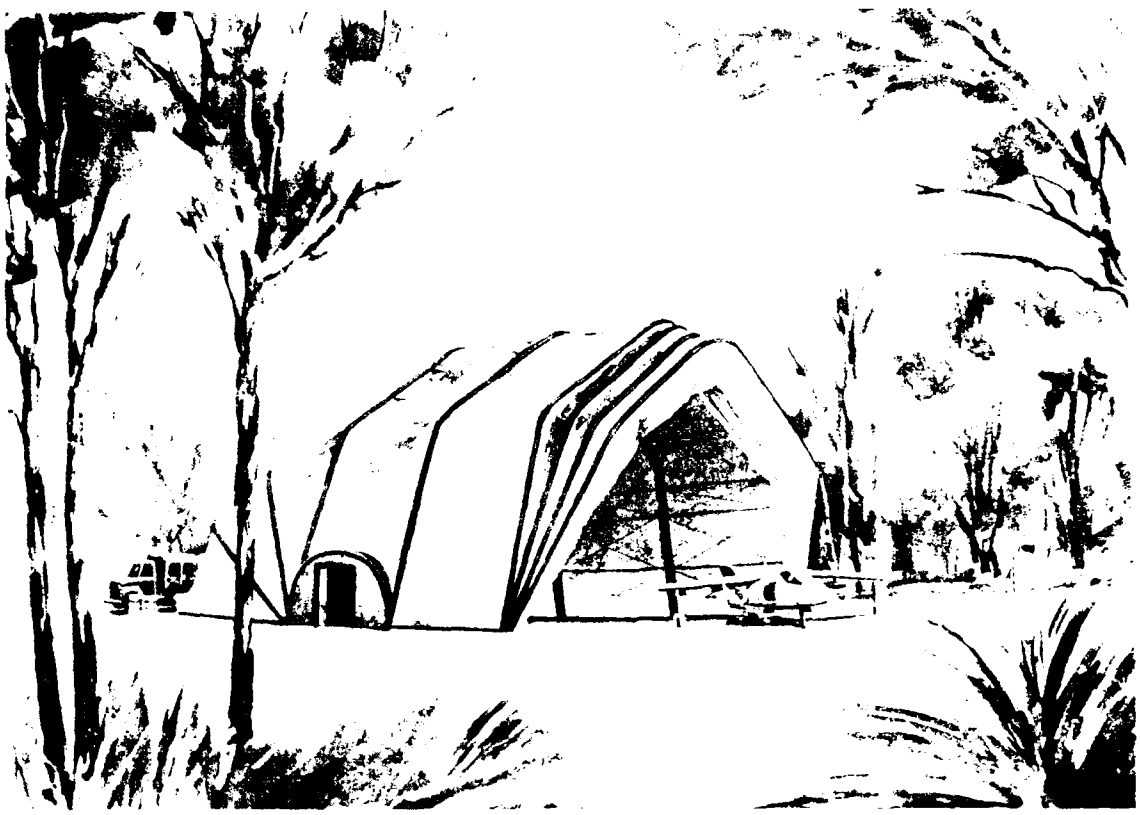

Figure 14. Rendering of TENSAR STRUCTURES' Shelter

14. CLAMSHELL BUILDINGS, INC., Santa Barbara, California

CLAMSHELL BUILDINGS, INC. (CBI) makes a shelter that meets the requirements for overall size, door openings, and loading (Figure 15). This concept has three types of frame components: two straight rectangular frame members of two different lengths, one curved section which becomes the eaves or peak, and fabric tensioned over the frame. CBI shelters have a clamshell-type door utilizing the same frame components as the body of the shelter. They can be erected from the ground without a crane. One drawback of this shelter is the large number of loose parts.

Type of Shelter	Frame and tensioned fabric structure.
Site Preparation	Same as an airfield.
Number of People to Erect Shelter	6 to 8
Number of Hours to Erect Shelter	12 to 16
Number of Hours to Dismantle Shelter	8 to 10
Special Equipment Required	Depending on the zone and/or soil conditions, different types of anchor-driving equipment will be required other than a sledge hammer (i.e., electric or gasoline hammer or auger-type drill).
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	Yes
An "Off-the Shelf" Item	Yes
Type of Modification Required	Reduce no. of loose parts.
Can be Shipped on a 463L Pallet	No, redesign of frame component required.
Shipped in an 8 by 8 by 20 ISO Container	Yes
Approx. Weight of Heaviest Item	175 pounds
Approx. Shipping Weight	21,000 pounds
Approx. Cubic Feet	1,000
Captive Fastening Devices	No, captive fasteners would have to be designed.

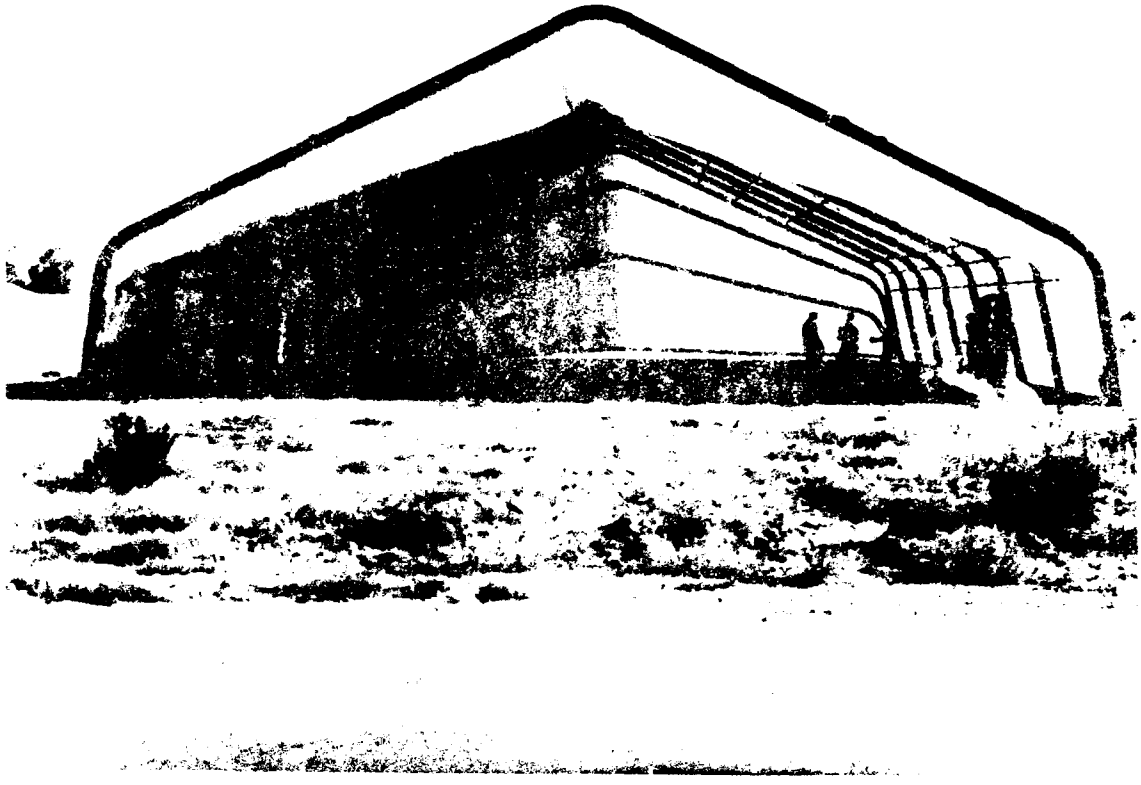

Figure 15. Rendering of CLAMSHELL BUILDINGS' Shelter

15. AIR STRUCTURES AIR TECH INTERNATIONAL, INC., Tappan, New York

This company is building a prototype shelter (60 by 100 by 30) with all frame components (I-Beams) the same size, and can be made any width by adding straight members (Figure 16). The fabric is tensioned over the frame. The door on each end is a catenary type door which needs to be modified to accept the designated aircraft. This shelter can be erected from the ground without a crane. AIR STRUCTURES already has a contract with a government agency to build 35 shelters.

Type of Shelter	Frame and tensioned fabric structure.
Site Preparation	Same as an airfield.
Number of People to Erect Shelter	6 to 8
Number of Hours to Erect Shelter	10 to 12
Number of Hours to Dismantle Shelter	6 to 8
Special Equipment Required	Depending on the zone and/or soil conditions, different types of anchor-driving equipment will be required other than a sledge hammer (i.e., electric or gasoline hammer or auger-type drill).
Meets Snow Loads	Yes
Meets Wind Loads	Yes
Has an Aircraft Doorway	Yes
An "Off-the Shelf" Item	Yes
Type of Modification Required	Enlarge present aircraft door.
Can be Shipped on a 463L Pallet	Yes
Shipped in an 8 by 8 by 20 ISO Container	Yes
Approx. Weight of Heaviest Item	200 pounds
Approx. Shipping Weight	22,750 pounds
Approx. Cubic Feet	1,100
Captive Fastening Devices	Yes

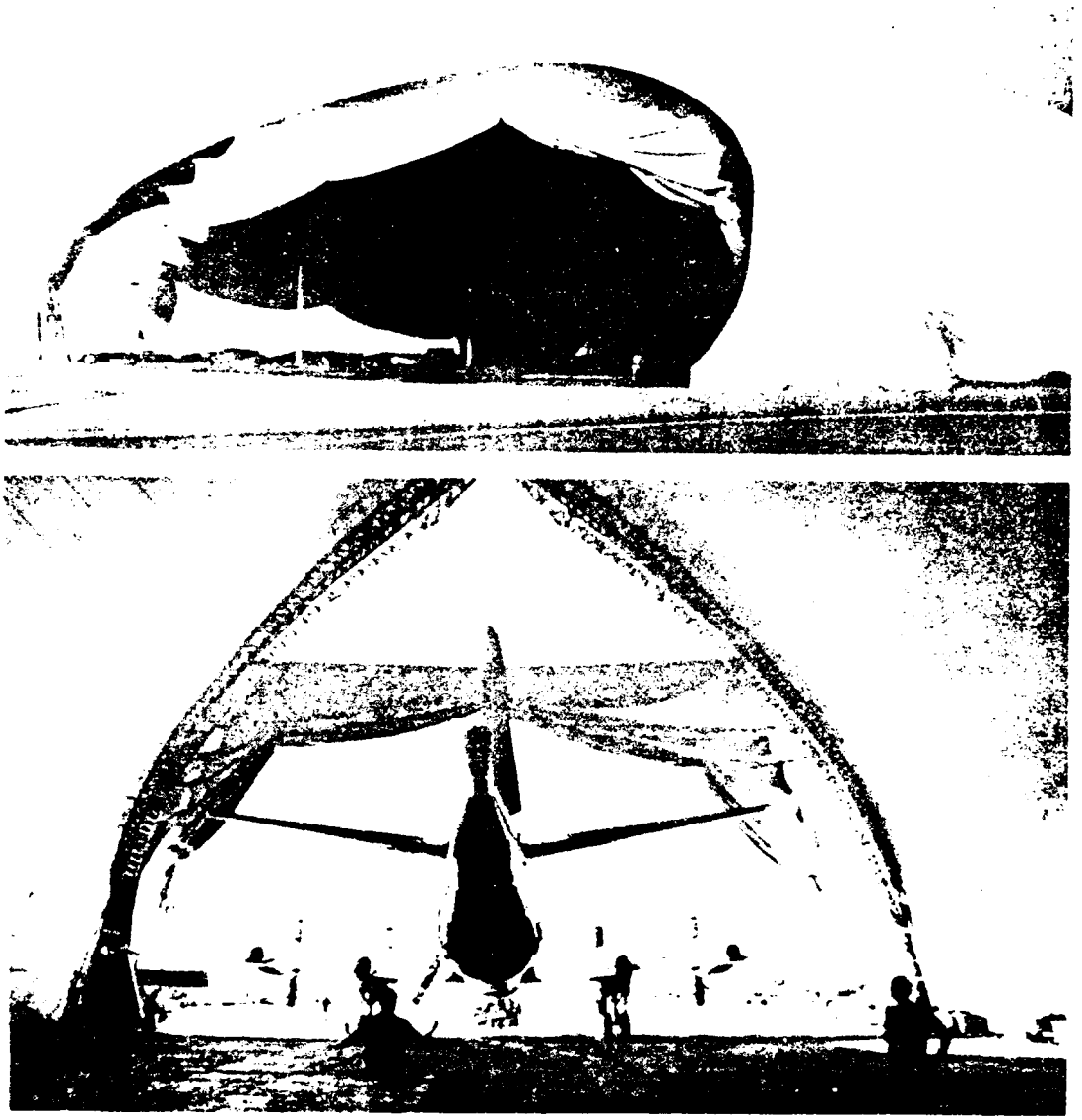

Figure 16. Rendering of AIR STRUCTURES' Shelter

SECTION III

OBSERVATIONS

CCI conducted an in-depth review of the data received from the 15 potential vendors to ascertain the existence of a commercially-available shelter which would meet the requirements set forth in the proposal. As of the date 22 March 1989, a shelter meeting all the Air Force requirements is not available.

Most responders could provide shelters which were either too large or too small. Door openings, unobstructed working space, and ease of erection proved to be formidable obstacles. Most companies indicated a willingness and ability to provide the shelter we desired. The responses from the second questionnaire were more realistic and narrowed down the field.

A number of European and Canadian firms were interested in providing a shelter and some designs were interesting, although shelters of the type sought were never produced by these companies. The American manufacturers were more in line with what the parameters and how best to conform to the required specifications. While their brochures did not portray any problems or hardware quantities, some furnished videocassettes depicting erection procedures. These provided invaluable information and in some cases eliminated the company from competition. Video cassette tapes were supplied by four companies. They are not provided with this report but may be viewed upon request.

We are firm in our belief that in engineering a shelter design, an area which requires a great deal of thought is on keeping the component parts required to a minimum number and capturing or securing loose parts. We sought a vendor(s) that would work closely with us to design a shelter with the features listed above which prove to be more economical over the life cycle of the system due to reductions in spare part replacement both in frequency of repair and quantity of lost parts.

In arriving at our decision to provide more than one shelter manufacturer as the final candidate, CCI determined that a combination of ideas from more than one company could be the best possible solution. Evidence of producibility was evident in the finalists' reports and our visitations supported their claims. The finalists will be discussed in the conclusions section of this report.

As part of the survey, CCI conducted a preliminary investigation into heating, cooling, and lighting. The results of this study depend on the final design and will be addressed in our Phase II proposal.

SECTION IV

CONCLUSIONS

The investigation revealed the three most viable candidates, who, with design modifications to their shelters, can provide the U.S. Air Force with a product which satisfies their requirements. These vendors, in the past and now, are building shelters that are as large or larger, than the subject shelter desired by the Air Force. They are being built for other Government agencies. All three vendors have vast amounts of experience in building this type of shelter. The principal investigator is familiar with each of the vendors' products and can attest to their workmanship and integrity.

Mr. Saab is well aware of the problem the Army has had with the loss of shelter parts during the erection and striking sequence as well as transportation. During an Army operation, several shelters had to be cannibalized to make one shelter usable. This creates problems with logistics and maintenance. With this type of information, a better, longer lasting, shelter could evolve, reducing the logistic support to a manageable level.

The following shelter manufacturers are, in our opinion, the best choices for furnishing this final product as desired by the U.S. Air Force with the minimum amount of design changes.

A. AIR STRUCTURES AIRTECH INTERNATIONAL, INC.

With offices in Tappan, NY and Sarasota, FL, this company has expertise in providing shelters to the military. At the present time, Air Structures is utilizing frame components comprised of much heavier beam sections than are required or desired for this contract. They have agreed to consider developing a lighterweight beam if chosen as the successful candidate. Our conversations with this vendor have determined that with a redesign effort which includes the refining of the door design and hardware, an acceptable shelter is possible. Air Structures has been a creditable manufacturer of shelter systems for a number of years and is fully aware of DoD requirements.

B. TENSAR STRUCTURES, INC.

A company with many years of experience in shelter design and manufacture, Tensar is currently in the process of producing a large, heavy duty shelter for the military. We have visited and talked to the staff at Tensar and believe that with a minor redesign effort similar to that of Air Structures (with the exception of the door which is close to the conceptional design), an acceptable shelter is, again,

possible. Tensar has experience in air-supported structures as well and is familiar with DoD requirements. We discussed the preparing of documentation with the engineering staff and feel confident in their capabilities. At the time of this report, Tensar is keeping us informed as to the progress of their shelter projects.

C. CLAMSHELL BUILDINGS, INC.

As a builder of shelters for the military, Clamshell Buildings is aware of the unique requirements that must be met in producing their product. Many hours of correspondence has insured us of their engineering capabilities as well as the ability to produce an acceptable shelter. The areas which require development are hardware containment and fabric types. One drawback to Clamshell may be their concern with unlimited rights in regards to the technical data packages. If this can be dealt with in an aggreeable manner, a shelter program could develop for the SBIR program.

To reiterate, these companies are presently in various stages of producing and delivering shelters of the type discussed in this report to various elements of the Department of Defense. CCI, having completed the assigned task, has concluded that our findings can be utilized successfully in a Phase II effort (providing the Air Force with a shelter, highly erectable, dome), which we are submitting forthwith.

The requirements for heating/cooling, lighting, and electrical power have been sought. The fact that no one shelter meets all of the requirements precludes any recommendations at his time. Our Phase II proposal will address the possibilities of these utilities in regards to the proposed effort to provide the Air Force with its required shelter.

REFERENCES

1. Tentage Reference Manual, Tentage and Organizational Equipment Branch of the Combat Support Division, Aero-Mechanical Engineering Directorate, U.S. Army Natick Research, Development, and Engineering Center, Natick, MA, September 1987.

2. Barca, F. D., Thermal Comfort in Tents, Aero-mechanical Engineering Laboratory, U.S. Army Research and Development Laboratories, Natick, MA, July 1981.

3. Thomas Register of American Manufacturing and Thomas Register Catalogue File, 73rd Ed., No. 1, 4, and 7, Thomas Publishing Company, New York, NY, 1983.

4. Who's Who in Canvas and Industrial Fabrics, Industrial Fabrics Association, St. Paul, MN, 1987.

APPENDIX A

FIRST MAILING TO 182 PROSPECTS

September 19, 1988

Gentlemen:

The U. S. Air Force has identified a requirement for a large, easily-erectable, and relocatable shelter to be used for flight-line aircraft maintenance. The shelter must be of sufficient size to house one aircraft (e.g., A-10, F-15, or F-16) and protect maintenance personnel from harsh environments such as temperature, wind and precipitation.

Compu-Cad, Incorporated is under contract to the Air Force to conduct an independent, objective survey of the shelter market to determine whether one or more commercially available shelters (with or without modifications) will satisfy this requirement. Overall criteria for the shelter are specified in the enclosure.

As a recognized provider of shelters, your input would contribute immeasurably to the scope of our survey. We would greatly appreciate any information you can provide on existing or potential products of your firm that would appear to match this requirement. Your response need not exactly match or be limited to, or by, the items listed in the enclosure, but we ask that it include:

1. A description of shelter design, materials, erecting/striking procedure and anchorage system.
2. Sketches and/or photos and brochures.
3. Intended use/application.
4. Source of obtaining shelter.
5. Dimensions of various available shelter sizes and associated costs.
6. Any specific, outstanding features of your shelter.
7. Listing of shelters sold by sizes and names of customers.

In order to complete our survey within the allotted time frame, we will need your response no later than November 1, 1988.

Your cooperation and support are greatly appreciated. Should you have any questions regarding this request, please feel free to contact either the undersigned or Mr. Ernest Saab at (508) 822-0554.

Sincerely,

COMPU-CAD, INCORPORATED

Richard P. Brilhante

RICHARD P. BRILHANTE

President

DESIGN AND PERFORMANCE OBJECTIVES

The following design and performance objectives encompass the general characteristics a shelter should have in order to be considered a feasible candidate:

Erectable in a 12 hour time period with a minimum of unskilled personnel (6-10, depending on size of shelter and weather conditions) using no special tools or equipment (i.e. forklifts or cranes) at unprepared sites.

Give protection to personnel from climate and provide for a comfortable working environment using liners, heating units (humidifying or dehumidifying units can be added if required), and ventilation.

A wide, unobstructed interior floor space (approximately 6500 square feet) free of structural members.

Lightweight: 100 -125 lbs. per component of the tent (max). The maximum length of each component should be approximately 12-15 feet.

Withstand wind loads of 50 MPH with gusts to 65 MPH, snow loads of 10# Sq. Ft. and temperatures of -50 F.)

A wide span door or doors capable of being opened in high wind velocity for access and egress of aircraft regardless of climate conditions to be approximately 65 ft.

Fabric of the shelter will withstand abuse in handling during erection, dismantling and packing for transportation.

Life cycle of 3-5 years with 4-6 erections per year and a storage life of 10-15 years.

Capable of being extended to house more than one aircraft.

Brunswick Corp.
1 Brunswick Plaza
Skokie, IL 60077

Flex O Span
PO Box 515
253 Railroad Avenue
Sandy Lake, PA 16145

Shenango Steel Buildings., Inc.
PO Box 268, Carbaugh Street
W. Middlesex, PA 16159-0268

Panelfab International Corp.
1600 N.W. Lejune Road
Miami, FL 33126

Sullivan Industries
103 Fremont Drive
Sanoma, CA

F E Carnie & Sons
2012 K Street
Sacramento, CA
(Fred Carnie)

Metallic Braden Buildings Co.
6300 W. Loops. Dept. TR
Bellair, TX 77401

HDO Production, Inc.
237 Melvin Drive
Northbrook, IL 60062
(Harry Oppenheimer)

Danville Tent & Awning Co.
1706 Warrington St.
Danville, IL 61832
(Bruce Wodetzki, Pres.)

Lafayette Tent & Awning Co.
125 S. 5th Street
Lafayette, IN
(H.J. Ebershoff. Pres.)

Pie In The Sky
P.O. Box 7190
Red Wood City, CA

Satellite Industries, Inc.
2532 Xenium Lane, North
Minneapolis, MN 55441

Rogers Manufacturing. Co
PO Drawer
3129 Ridge Land Road
Kingston, NC 28501

Swiss Fabrication, Inc.
1953 Camp Horne Road
Pittsburgh, PA 15237

CID Associates, Inc.
PO Box 445, Dept. 6
Oakmont, PA 15139

Delta Steel Building Systems
PO Box 20977
Dallas, TX 75220

Anchor Industries, Inc.
PO Box 3477
1100 Burch Drive
Evansville, Indiana 49733

Georgia Tent & Awning Co.
228 Margaret S. E.
Atlanta, GA 30315
(Robert Spooner)

Fabric-Tech, Inc.
13333 Britton
Nobelsville, IN
(Don Menchhofer. Pres.)

American Tent & Awning
636 S. East Street
Indianapolis, IN
(Terrance Simpson. Pres.)

Muehleisen Manufacturing Company
Div. Baldwin-Green. Inc.
PO Box 8130
San Diego, CA 92102-0130

Alpha Structures
PO Box 22300
Lexington. KY 40522

Arthur Industries
PO Box 74
S. Main Street
Terryville, CT 06786

Air Supported Structures
7600 Wall Street
Cleveland, OH 44125

Connel Bros. Co., LTD.
320 California Street
San Francisco, CA 94104

American Partitions
18335 Mt. Langley Street
Fountain Valley, CA 92708

Modulaire Industries
744 Montgomery Street
San Francisco, CA 94104

Williams Mobile Officers
PO Box 986
Baltimore, MD 21203

Relco Corp.
74 Relco Drive
N. Billerica, MA 01862

Arctic Structures, Inc.
Department T
PO Box 2142
Anchorage, AK 99510

Alaska Tent & Tarp, Inc.
529 Front Street
Fairbanks, AK 99701

Louisville Tent & Awning
2553 Cannon
New Albany, IN

Burch Manufacturing Company
618 First Avenue
Fort Dodge, IA

Mason City Tent & Awning
408 S. Federal
Mason City, IA

Air Tech/IRVIN Industries
85 Madison Circle Drive
East Rutherford, NJ 07073

Bird Air Structures
Div. of CHEMFAB
2015 Walden Avenue
Buffalo, NY 14225

Bally Case & Cooler, Inc.
5 Third Street
Bally, PA

National Partitions & Interiors, Inc.
340 W 78th Road
Hialeah, FL 33014

Abercrombie & Kent
1000 Oak Brook Road
Oak Brook, IL 60521

Design Structures
140 West Charles Rd.
Villa Park, IL 60181

Tent Hut
80 West Commercial Avenue
Moonachi, NJ 07074

Mobile Facility Engineering Inc.
306 W State
Cassopolis, MI 49031

Irvin Industries, Inc.
Structure Division
1315 Versvilles Drive
Lexington, KY 40504

Linblad Corp.
528 Viking Drive
Virginia Beach, VA 23452
(C. Lindblad)

Magline, Inc.
1949 Mecer Street
Pinconning, MI 48650

F & H Manufacturing Corp
25 Power Drive
Hauppaug, NY 11787

Colman Co., Inc.
250 N. St. Francis Street
Wichita, KS

Langdon Protective Covers, Inc.
PO Box 110276
Wichita, KS
(Walt Aikman)

Hoigaards, Inc.
3550 S. Highway 100
Minneapolis, MN
(Conrad Hoigaard)

Wenzel Company
P O Box 7048 A
St. Louis, MO 63177
(Tim J. Hinds)
314-576-3200

Herculite Products, Inc.
1107 Broadway
Suite 900
New York, NY 10010

Wagner Awning & Manufacturing Company
Industrial Products Division
2658 Scranton @ Barbers Avenue
Clevaland, OH 44113

Camel Manufacturing Company
Department TR
PO Box 835
Knoxville, TN 37920

Environmental Structures Co.
7600 Wall Street
Cleveland, OH 44125
216-524-9270

Clamshell Buildings
1206 Coast Village Circle
Suite J
Santa Barbara, CA 93108
(Roly Hunt)

Porta King Building Systems
Shore Line Drive @ Parks Steed Dr.
Earth City, MO 63045

Seahorse Plastic Corp.
4860 Shoulder Hill Rd.
Suffolk, VA 23435

Neider Meyer Martin Co.
1727 N. 11th Avenue
PO Box 37568
Portland, OR 97208

Design Space International
P O Box 7100
Bala Cyn Wyn, PA 19004

Air Structures International, Inc.
30-32 Rockland Park Avenue
Tappan, NY 10983
(D. Fraioli, Pres.)

Seaman Building Systems
2028 E. Whitefield Ave.
Sarasota, FL 33580

Tarcom Corp.
PO Box 326
Lake Zurich, IL 60047

Armbruster Manufacturing Co.
8601 Old Rte 665
Springfield, IL 62707
(Bernard Armbruster, Pres.)

Porth Fab Corporation
Grissom Drive
St. Louis, MO 63141

Brooks & Perkins
201 Haynes Street
PO Box 550
Cadillac, MI 49601
(Jim Sherwood)

Puria Kamp Manufacturing Co.
PO Box 7064
Houston, TX 77248

Starrco Co., Inc.
1513 Fairview Avenue
St. Louis, MO 63132

Goodyear Aerospace Corp.
PO Box 9278
Akron, Ohio 44305

Porta-Green Co.
7600 Wall Street
Cleveland, OH 44125

Temcor, Inc.
2827 Toledo Street
Torrance, CA 90503

ParaBam, Inc.
1130 Watsow Center Rd.
Carson, CA 90745

Craig Systems Inc.
10 Industrial Way
Amesbury, MA 01943-4848

Advance Structures Corp.
235 W. Industry Court
Deer Park, NY 11729

Modular Engineering Co.
PO Box 8241
Erie, PA 16505

Vaughan & Associates, Inc.
1225 Round Table Drive
Dallas, TX 75247

Keystone Structures, Inc.
38 S. 19th Street
Philadelphia, PA 19103

Midwest American Shelter Systems
210 Hayes Drive
Cleveland, OH 44131

Plastimayd Corp.
14450 SE 98th Court
PO Box 1550
Clackams, OR 97015

Arch Technology Corp.
PO Box 6
Plato Center, IL 60170

Southern Structures
3105 Third Street
Icala, FL 32671

Sioux Falls Structures
RR 40, Box 40
Sioux Falls, SD 57101

Hemisphere Steel Product Corp.
54 N. 11th Street
Brooklyn, NY 11211

Lawrence Canvas Products Co.
1532 S. Kings Highway
St. Louis, MO 63132

Aero Fab, Inc.
1 High Street
Sanford, ME 04073

Air Cruisers Company
PO Box 180
Belmar, NJ 07719-0180

Unistrut Corp.
777 Eisenhower Park
Suite 600A
Ann Arbor, MI

ABCO Fab Industries
PO Box 825
Flushing, NY 11354

CR Daniels, Inc.
Industrial Division
3453 Ellicot Center Drive
Ellicott City, MD 21043

Dorcester Awning Company
PO Box 385
230 Oak Street
Pembroke, MA 02359
(W. J. Swanson, Pres.)

BIG Enterprises
9702 East Rush St.
S. Elmonti, CA 91733-1731

Air O Structures
240 River Bend
Lewinston, ME 04240

Alturdyne
8050 Armour Street
San Diego, CA 92111

RUBB, Inc.
PO Box 711
Sanford Municipal Airport
Sanford, ME 04073

SEE Design & Production, Inc.
2215 Claxter Road, N.E.
Salem, OR 97303
(Spencer Etzel, Pres.)

Para Tech Engineering Co.
Div. Sew Tech Engineering, Inc.
10076 Rockville B
Santee, CA 92071
(Donald Whilldin, Pres.)

Protech Pacific
1221 Anderson Drive
San Rafael, CA 94901
(Linda Dixon)

Shelter System
PO Box 38
Crested Butte, CO 81224

Mathison Magnesium, Inc.
W. 246-53245 Industrial Lane
Waukesha, WI 53186

Menta Products Corp.
62 East Main Street
Babylon, NY 11702

Billings Work Shop, Inc.
200 South 24th Street
Billings, MT 59101
(Larry Hudson)

Kings Point Manufacturing Co.
219 Gray Street
Fayetteville, NC 28302

Exploration Products
1815 Lewis Street
Spokan, WA 99204

Span Systems
180 Morris Avenue
Mountain Lake, NJ 07046

Sprung Instant Structures
1010 10th Avenue
SW Calgary, Alberta Canada TEROB

Tensar Structures
PO Box 212
1335 Bloomingdale Road
Akron, NY 14001
(Walter Zelasko)-116-342-5888

Nordam
510 S. Lansing
Tulsa, OK 74120

Tilko Designs, Inc.
23761 Eden Avenue
Haywood, CA 94545
(Gerald Tilley, Pres.)

American Awning, Inc.
520 Nottingham Boulevard
West Palm Beach, FL 33405
(Scott Tengzelius)-407-832-7123

Phaff & Kendal
84 Foundry Street
Newark, NJ 07105

Wire Industries
2250-4 Center Terrace
Grand Island, NY 14072

Universal Unlimited, Inc.
3218 Leopold Street
PO Box 4107
Corpus Christi, TX 78408
(Ed Canto, Pres.)-512-822-7890

B F Goodrich
Aerospace and Defense Div.
1555 Corporate Woods Pkway.
PO Box 1299
Uniontown, OH 44685-1299

LaCross Tent & Awning Co.
2127 George
LaCross, WI 54603

Reliable Tent & Awning
120 N. 18th Street
PO Box 1271
Billings, MT 59103
(Robert Nemer, Pres.)

ATCO Structures Inc.
12200 E. Iliff Avenue
Suite 204, Building C
Aurora, CO 80014-1251

Midwestern American Inc.
PO Box 40338
Houston, TX 77240

Van Doren Industries Inc.
PO Box 1008
Hays, KS 67601

Coronis Building Systems Inc.
Jobtown Road
Columbus, NJ 08022

Williams-Modular Structures
PO Box 183
Pelham, NH 03076-0183

Gelco Space
PO Box 7100
Bala Cynwyd, PA 19004

Span Dome Corporation
180 Morris Avenue
Mountain Lake, NJ 07046

A&S Building Systems
10555 W. Little York Road
PO Box 40099
Houston, TX 77240

Normadic Structures
7700 Southern Drive
Spring Field, VA 22150

Professional Systems Inc.
PO Box 1224
Waukesha, WI 53187

Starnet Structures Inc.
106 A Bell Street
West Babylon, NY 11704

(Dolores Sloggy)
Fibremart Designs, Inc.
PO Box 764
Pont Vedra Beach, FL

Thermo Flex, Inc.
PO Box 1184
Salina, KS 67402

Air Supported Structures
PO Box 387
Monmouth, ME 04259

Aerodome Industries Inc.
2716 George Washington Blvd.
Wichita, KS 67210

Port A Port
2711 Arnold Avenue
Salina, KS 67401

Erect-a-tube
PO Box 100
Harvard, IL 60033

Austin Fabrication Co. Inc.
212 N. Albany Avenue
Atlantic City, NJ 08401

Mobile Office Co.
Jackson and Taunton Rd
Berlin, NJ 95307

A&L Product Inc.
1840 E. Whitmore Avenue
Ceres, CA 95307

MacLander Inc.
925 Furnas Drive
Osceola, IA 50213

Y.E.P. Industries Inc.
PO Box 1702 Industrial Park
York County
York, PA 17405-1702
Rail Quip Inc.
3731 North Crest Road
Suite 6
Atlanta, GA 30340

Skytech Systems
Colombia County Industrial Park
PO Box 763
Bloomsburg, PA 17815

Arches Metal Building Systems
244 Executive Plaza Road
Unit 3
Pensacola, FL 32504

Cathos Corporation
PO Box 528
Princetown, NJ 08540

ABCOTEK Technology Co. Inc.
151 23A 34th Avenue
Flushing, NY 11354

International Shelter Systems Inc.
PO Box 565
Cockeyville, MD 21030

Prime Building Systems
1461 NW 72nd Avenue
Plantation, FL 33313

Clear Span Component Inc.
PO Box 4195
Meridan, MS 39304

Space Master Building
Department 2
25 Dorchester Avenue
Boston, MA 02205

Jovanovic Internationl Inc.
274 County Road
Tennfly, NJ 07670

Fulfab Inc.
1525 SW Whipple Street
Canton, OH 44710

Foreign Tent Manufacturers

Alberta Tent & Awning Co., Ltd.
Bay 11, 3500 27th Street
N.E. Calgary, Alberta, Canada TTYSE2-6
(Borge Pedersen, Pres.)

Edmonton Tent & Awning
14730 118th Avenue
Edmonton, Alberta T5L-2M8
(Vern Nast, Gen. Mgr.)

Northwest Tent & Awning Co., Ltd.
11311 120th Street
Edmonton, Alberta T5G-241
(Alvin Bryant, Pres.)

Warner Shelter Fabrics Structures
1740 12th Avenue
S.E. Calgary, Alberta TGZ-5CZ
(Kurt Warner, Pres.)

Project Shelter, Ltd.
14 West 5th Avenue
Vancouver, British Columbia V5Y1HB
(Gabriel Dinim, Pres.)

Alpha Tent & Awning LTD
201-2984 Norland Avenue
Burnaby, British Columbia VBB3A6
(William McMillian)

Ancient Mariner, LTD.
15 East 2nd Avenue
Vancouver, British Columbia V5T-1B3
(Gary Taylor, Pres.)

Cambridge Canvas Center, LTD
Industrial Road
Cambridge, Ontario N3H4S1
(William Campbell, Pres.)

Fel-Fab International, Inc.
PO Box 3303, Station C
Hamilton, Ontario L8H7L6
(D. R. Fell, Gen. Mgr.)

L P Systems
1157 Blair Road
Burlington, Ontario 67M1P9
(Bernt Ivarsson, Pres.)

Mustang Industries, Inc.
3810 Jacombs Road
Richmond, British Columbia V6V1Y6
(Dwight Davis, Pres.)

UCO N.V
Bellevue 9218 Leederberg
Gent, Belgium
(Pierce Baeten, Div. Mgr.)

Georges Veldeman N.V.
Industrial Zone, Vostaert
3690 Bree, Belgium
(George Veldeman, Dir.)

Barrier Consolidated Ind. Pty.
Unit 3, 37 Church Avenue
Mascot NSW, Australia 2020

LosBerger GMBH., Co. KG
7 Hans Riesser Strasse
Postfach 2540, Heilbronn 7100
(Hans Schergel)

Roeder GMBH
Am Lautenstein D6470
Buedigen 7
Federal Republic of Germany
(Heinz Roeder)

Taiyo Kogyo Corp.
3-22-1 Higashiyama
Meguro-Ku, Tokyo 153 Japan

Korea Tarpaulin, Inc.
PO Box 2420
Seoul, Korea

Yeadon Fabric Structures, LTD
550 Imperial Road
N. Guelp, Ontario N1HGR1
(David Buckley)

Gotschalk Co. GMBH
PO Box 101440
D3500 Kassel
Federal Republic of Germany
(Werner Bitter)

Schmitz-Wetzke GMBH & Co.
PO Box 1243 Hawsestrasse 7
4407 Emsdetten
Federal Republic of Germany
(Carl Hinderich Schmnitz, Pres.)

Ken Low, Pty. Ltd.
1970 Albany Highway
Maddington, W. Australia 6159

Karl Hoecker Stahlbau GMBH&Co KG
4 1M Weingarten 4902 Bad Salzuflew 5
Federal Republic of Germany
(Rudolf Hoecker)

Maruman Sangyo Co. Ltd.
8 Chome Kamata Cho
Minami-ku, Nagoya 457, Japan

Yano Tent Co., Ltd.
3-21 5 Shome Wakeminamimachi
Higashi Dsaka, Japan

Hood Structure Flex
Westhaven Drive
St. Mary's Bay
Auckland 1, New Zealand

APPENDIX B

SECOND MAILING TO 15 FINALISTS

December 20, 1988

Attention:

Dear Mr. :

We wish to thank you for the information you supplied to us relative to your approximate 9600 square foot shelter system. Your information was most helpful to us in conducting an industry study to determine whether one or more shelter systems exist in the private sector that satisfy an urgent Air Force requirement. As a result of the first phase of our study, it appears that your shelter system meets the general requirements.

The second phase of our study requires a little more depth in terms of specific details. Once more we solicit your assistance. We would appreciate any additional information you could provide to us relative to the following specific items:

1. What, if any, provisions are included in your shelter system for heating, and can you provide specification fuel, power consumption, BTUs, etc.) and cost data for your heating system? If you shelter system does not heat, do you, or can you, offer any recommendations?

2. Does your shelter system include provisions for liners to aid in temperature control? Can you supply details regarding material, mounting technique, cost and R/U factors, and any associated test data you may have acquired?

3. Does your shelter system have integral lighting, and can you supply specifications (e.g., voltage current, circuit breakers, foot candles, etc.)?

4. Does your shelter system have an integral electrical system, and can you supply specifications (e.g., circuit breaker panels(s), number of outlets, outlet layout, etc.)?

5. If your shelter system includes a repair kit and/or spare parts, can you supply listings?

6. Please provide any information, test data, calculations, specifications and/or certificates or compliance you have relative to:

A. Wind/snow load capabilities
B. Flame resistance/fire retardation
C. Fungus resistance
D. Petroleum, oil and lubricant (POL) resistance

7. Would you indicate locations where your shelter system is installed so that we might visit an operational site which is 9600 square feet or larger?

8. How many manhours are required to erect this shelter?

9. Does your shelter require special tools or equipment?

10. Does your shelter require foundation preparation?

11. What is the cost per square foot (shelter only)?

12. What is the packaged ;cubic feet or your shelter?

This information will be of great assistance in helping us determine how closely your shelter system matches the Air Force requirement. We would greatly appreciate your input on or before 15 January 1989. A few of the vendors have supplied us with VHS video tapes depicting erection and striking of their product. This would be very helpful to us if you have such a tape.

Should you have any questions, please feel free to contact Mr. Ernest Saab, or myself, at (508) 822-0554.

Very truly yours,

COMPU-CAD, INCORPORATED

RICHARD P. BRILHANTE
President

RPB:jb

CHEMFAB
One American Drive
Buffalo, NY 14225
(Mr. Mark Sinoffky)

Hoecker Inc.
10595 Killarny Dr.
Union, KY 41091

LosBerger GMBH & Co., KG
Hans-Riesser Strasse 7
PO Box 2540, D-7100 HeilBronn
Federal Republic of Germany
(Mr. Walz)

Clamshell Building Inc.
1206 Coast Village Circle
Suite J
Santa Barbara, CA 93168
(Mr. Roly Hunt)

Tensar Structures
13550 Bloonmingdale Road
Akron, OH 14001
(Mr. W. Zelasko)

Nordam
510 South Lansing
Tulsa, OK 74120

ATCO Structures, Inc.
12200 E Iliff Avenue
Suite 204 Bldg. C
Aurora, CO 80014-1251

Little River Industries Inc.
PO Box 505
Quincy, FL 32351-0505
(Mr. Ward)

Arch Technology Corp.
PO Box 6
Plato Center, IL 60170
(Mr. Victor Lee)

Roder USA
1096 Madison Place
Laguna Beach, CA 92651
(Mr. Peter George)

Warner Shelter Corp.
150 E 1st Avenue
Vancouver, B.C V5T-1A4
(Mr. Gary Warner)

Air Structures - Air Tech
International Inc.
30-35 Rockland Park Ave
Tappan, NY 10983

Sprung Instant Structures
1001 10th Avenue
Calgary, Alberta T2R-087
(Mr. F. B. Iruine)

A&L Products
1840 Whitmore Avenue
Ceres, CA 95307
(Mr. Beewith)

Erect A Tube
PO Box 100
Harvard, IL 60033
(Mr. C. McQueen)

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